

JC05 Rec'd 27 MAR 2002

FORM PTO-1390 (REV. 9-2001)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER NOK114-00025
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371			U.S. APPLICATION NO. (If known, see 37 CFR 1.5) <b>10/089326</b>
INTERNATIONAL APPLICATION NO. PCT/IB00/01434	INTERNATIONAL FILING DATE 27 September 2000	PRIORITY DATE CLAIMED 29 September 1999	
TITLE OF INVENTION MULTILAYER TELECOMMUNICATIONS NETWORK			
APPLICANT(S) FOR DO/EO/US Jori Arrakoski, Ari Leppa, Nico, Van Waes			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:			
<p>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</p> <p>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</p> <p>3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.</p> <p>4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31).</p> <p>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))</p> <p>a. <input checked="" type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</p> <p>b. <input type="checkbox"/> has been communicated by the International Bureau.</p> <p>c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</p> <p>6. <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</p> <p>a. <input type="checkbox"/> is attached hereto.</p> <p>b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4).</p> <p>7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))</p> <p>a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</p> <p>b. <input type="checkbox"/> have been communicated by the International Bureau.</p> <p>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</p> <p>d. <input type="checkbox"/> have not been made and will not be made.</p> <p>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).</p> <p>9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</p> <p>10. <input type="checkbox"/> An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</p> <p><b>Items 11 to 20 below concern document(s) or information included:</b></p> <p>11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</p> <p>12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</p> <p>13. <input checked="" type="checkbox"/> A <b>FIRST</b> preliminary amendment.</p> <p>14. <input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment.</p> <p>15. <input type="checkbox"/> A substitute specification.</p> <p>16. <input type="checkbox"/> A change of power of attorney and/or address letter.</p> <p>17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.</p> <p>18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).</p> <p>19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).</p> <p>20. <input checked="" type="checkbox"/> Other items or information:</p> <p>A. Certificate of Mailing by Express Mail</p> <p>B. Postcard Receipt</p>			

U.S. APPLICATION NO. (if known) <b>107089326</b> INTERNATIONAL APPLICATION NO. PCT/IB00/01434		ATTORNEY'S DOCKET NUMBER NOKI14-00025	
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21. <input checked="" type="checkbox"/> The following fees are submitted: <b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... <b>\$1040.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$890.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... <b>\$740.00</b> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$710.00</b> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ..... <b>\$100.00</b> <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>				<b>CALCULATIONS PTO USE ONLY</b>	
Surcharge of <b>\$130.00</b> for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).					
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	35 - 20 =	15	x <b>\$18.00</b>		
Independent claims	5 - 3 =	2	x <b>\$84.00</b>		
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ <b>\$280.00</b>		
<b>TOTAL OF ABOVE CALCULATIONS</b>			= <b>\$ 438.00</b>		
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			+		
<b>SUBTOTAL</b>			= <b>\$ 1328.00</b>		
Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).			\$		
<b>TOTAL NATIONAL FEE</b>			= <b>\$ 1328.00</b>		
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property +			\$		
<b>TOTAL FEES ENCLOSED</b>			= <b>\$ 1328.00</b>		
			Amount to be refunded:		
			charged:		

a. ☒ A check in the amount of \$ 1328.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 50-0208 in the amount of \$ \_\_\_\_\_ to cover the above fees.  
 A duplicate copy of this sheet is enclosed.

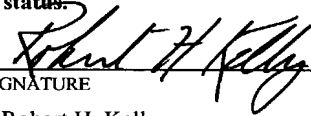
c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any  
 overpayment to Deposit Account No. 50-0208. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card  
 information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR  
 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

  
 SIGNATURE  
 Robert H. Kelly  
 NAME  
 33,922  
 REGISTRATION NUMBER

DOCKET NO. NOKI14-00025

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: : JORI ARRAKOSKI ET AL.  
International Appl. No. : PCT/IB00/01434  
International Filing Date : 27 September 2000  
Title : MULTILAYER TELECOMMUNICATIONS NETWORK

**BOX PCT**

Commissioner for Patents  
Washington, D.C. 20231

Sir:

**PRELIMINARY AMENDMENT**

Please amend the above-identified patent application as follows:

**IN THE CLAIMS:**

Please cancel claims 1-35 and substitute therefor, claims 36-70 as follows:

36. A communications system comprising:
- a first network comprising a plurality of first network subscriber units and a first network sink node unit capable of wireless communication with the first network subscriber units;
  - and
  - a second network geographically at least partly overlapping the first network and comprising a plurality of second network subscriber units and a second network sink node unit capable of wireless communication with the second network subscriber units; and

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a dedicated connection between the first network sink node unit and a second network unit capable of communication in the second network, whereby a first network subscriber unit may be provided with a communication path to another second network unit.

37. A communications system as claimed in claim 36, wherein wireless communication in the first network is independent of wireless communication in the second network.

38. A communications system as claimed in claim 37, wherein wireless communication in the first network is in a different frequency band from wireless communication in the second network.

39. A communications system as claimed in claim 38, wherein the first network comprises a plurality of first network sink node units with which the first network subscriber units are capable of wireless communication.

40. A communications system as claimed in claim 39, comprising a plurality of a dedicated connections, each dedicated connection being between a respective first network sink node unit and a respective second network unit whereby a first network subscriber unit may be provided with a communication path to another second network unit.

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41. A communications system as claimed in claim 40, comprising:

a third network geographically overlapping the second network and comprising a plurality of third network subscriber units and a third network sink node unit capable of wireless communication with the primary third network unit; and

a dedicated connection between a second network sink node unit and a third network unit capable of communication in the third network, whereby a second network subscriber unit may be provided with a communication path to another third network unit.

42. A communications system as claimed in claim 41, wherein wireless communication in the first network and in the second network is independent of wireless communication in the third network.

43. A communications system as claimed in claim 42, wherein wireless communication in the first network and in the second network is in a different frequency band from wireless communication in the third network.

44. A communications system as claimed in claim 43, wherein the second network comprises a plurality of second network sink node units with which the second network subscriber units are capable of wireless communication.

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45. A communications system as claimed in claim 44, comprising a plurality of a dedicated connections, each dedicated connection being between a respective second network sink node unit and a respective third network unit whereby a second network subscriber unit may be provided with a communication path to another third network unit.

46. A communications system as claimed in claim 45, wherein the said communication is data communication.

47. A communications system as claimed in claim 46, wherein the said communication is packet data communication.

48. A communications system as claimed in claim 47, wherein the said communication said communication uses an internet protocol.

49. A communications system as claimed in claim 48, wherein the said communication in the first network is radio communication.

50. A communications system as claimed in claim 49, wherein the said communication in the second network is radio communication.

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51. A communications system as claimed in claim 50, wherein the said communication in the third network is radio communication.

52. A communications unit for operation in a communications system including a first network comprising a plurality of first network subscriber units; and a second network geographically at least partly overlapping the first network and comprising a plurality of second network subscriber units and a second network sink node unit capable of wireless communication with the second network subscriber units; the communications unit being operable as a first network sink node unit capable of wireless communication with the first network subscriber units and having a dedicated connection to a second network unit capable of communication in the second network, whereby a first network subscriber unit may be provided with a communication path to another second network unit.

53. A method for providing a communication path in a communications system comprising: a first network comprising a plurality of first network subscriber units and a first network sink node unit capable of wireless communication with the first network subscriber units; and a second network geographically at least partly overlapping the first network and comprising a plurality of second network subscriber units and a second network sink node unit capable of wireless communication with the second network subscriber units; the method comprising providing a dedicated connection between the first network sink node unit and a second network unit capable

of communication in the second network, whereby a first network subscriber unit may be provided with a communication path to another second network unit.

54. A communications system comprising:

a first network comprising a first sink node and a plurality of first communication terminals capable of wireless communication with the first sink node;

a second network level geographically at least partly overlapping the first network and comprising a second sink node and a plurality of second communication terminals capable of wireless communication with the second sink node; and

the first sink node being further capable of operation as a second communication terminal for providing the first communication terminals with communications access to the second network.

55. A communications system as claimed in claim 54, wherein wireless communication in the first network is independent of wireless communication in the second network.

56. A communications system as claimed in claim 55, wherein wireless communication in the first network is in a different frequency band from wireless communication in the second network.



60. A communications system as claimed in claim 59, wherein wireless communication in the first network and in the second network is independent of wireless communication in the third network.

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61. A communications system as claimed in claim 60, wherein wireless communication in the first network and in the second network is in a different frequency band from wireless communication in the third network.

62. A communications system as claimed in claim 61, wherein the second network comprises a plurality of second network sink node units with which the second network communication terminals are capable of wireless communication.

63. A communications system as claimed in claim 62 as dependent directly or indirectly on claim 24, comprising a plurality of a dedicated connections, each dedicated connection being between a respective second network sink node unit and a respective third network whereby a second network communication terminal may be provided with a communications access to the third network.

64. A communications system as claimed in claim 63, wherein the said communication is data communication.

65. A communications system as claimed in claim 64, wherein the said communication is packet data communication.

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66. A communications system as claimed in claim 65, wherein the said communication uses an internet protocol.

67. A communications system as claimed in claim 66, wherein the said communication in the first network is radio communication.

68. A communications system as claimed in claim 67, wherein the said communication in the second network is radio communication.

69. A communications system as claimed in claim 33, wherein the said communication in the third network is radio communication.

70. A communications unit for operation in a communication system including a first network comprising a plurality of first communication terminals; a second network geographically at least partly overlapping the first network and comprising a second sink node and a plurality of second communication terminals capable of wireless communication with the second sink node; the communications unit being operable as a first sink node capable of wireless communication terminal for providing the first communication terminals with communication access to the second network.

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**REMARKS:**


Substitute claims 36-70 set forth above are believed to place the application in condition for the Examiner's early examination and consideration for allowance. Examination and consideration for allowance of such claims is respectfully requested.

Respectfully submitted,

NOVAKOV DAVIS &amp; MUNCK, P.C.

Date: 27 May 02

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**MULTILAYER TELECOMMUNICATIONS NETWORK**

This invention relates to a multilayer telecommunications network.

A wireless telecommunications network conventionally comprises a plurality of subscriber terminals such as mobile phones or wireless local loop terminators which can each communicate with one or more nearby base stations. Each base station is connected to a base station controller or another network element connecting the base station to the rest of the network by a relatively high bandwidth connection such as a cable or fibre link. Each base station controller is connected to a number of base stations. The base station controllers are connected to other network equipment, and by means of that equipment to other networks. In this way a connection can be established from one subscriber terminal to another or to a terminal in one of the other networks.

This arrangement has a number of disadvantages. First, it is necessary to implement all levels of the network in order to provide any connectivity for subscriber terminals. Second, all subscriber terminals use a similar link to a base station, and therefore it is not possible to offer subscriber terminals that can communicate at significantly enhanced data rates. Third, the hierarchical nature of the network-side connections to each base station mean that it is relatively inconvenient to alter the deployment of base-stations.

A fully wired connectivity concept is currently being deployed for many applications, for example using low speed telephone modems, DSL technologies, ISDN, cable modems, fibre etc. However, with current non-DSL technology the available throughput is relatively low for many intensive applications. DSL throughput is often degraded due to insufficient backhaul capacity and excessive traffic bundling. Also, DSL is often limited to urban scenarios due to the strict distance limitations.

Another one tier wireless solution is a fully PMP (LMDS) network. The main advantage the proposed network has over this solution, is that it does not suffer from the stringent LOS requirements of this type of solution, and that the CPE devices for low-demand customer premises will be far less expensive due to the lower cost of the RF part.

figure 12 shows IMS spectrum band allocation;

It is significant that each tier can "fit seamlessly", in terms of connectivity and interference avoidance, in the multi-tiered architecture. But tiers are preferably not interoperable because, for example, they may each operate in a different frequency band. This would avoid inter-tier interference.



In comparison, previously disclosed networks typically consist of one tier only, which neither provide scalability nor are designed with lower or higher wireless network tiers in mind.

As will be described in more detail below, further network tiers (for example WLANs or PANs) may be attached on top of or below the network of figure 2. These further tiers may operate within the same frequency band, CCA may be employed to allow for graceful coexistence within such a frequency band. It is preferred that devices meant for operation in the Ad-hoc Mesh Tier will be capable of interoperability with WLANs. This would allow such devices to be able to switch operation from one tier into the other.

The word "connectivity" refers to the possibility to connect co-located devices from different tiers back to back. The word "interoperability" refers to the capability of a device made to function in one tier in a certain mode, to function in another tier in that same mode.

A multi-tiered architecture of the type shown in figure 2 can provide flexible and scalable network deployment, which provides high cost-efficiency. Especially in the mesh architecture of the lowest tier, increasing the throughput can easily be achieved by inserting only a new node into the tier above, without manual reconfiguration of any other devices. In contrast, in a one-tier approach increasing bandwidth demand often can only be met by a total reconfiguration of the whole (sub)-network. This flexibility and scalability can give a network operator the ability to start the network small and extend it as demand increases, whereas other networks generally need to be fully pre-deployed (e.g. wired networks), or pre-deployed to a large extent to avoid the huge cost of network extension (e.g. one-tier wireless approaches).

A multi-tiered architecture can also avoid the need for a trade-off between technology cost and performance demands. For a one-tiered network, for example a network in the LMDS band, throughput can be made adequate

throughout the network, but the cost of a CPE is high due to the high cost of RF-technology in this band. For a one-tiered network in the 2.4 GHz band, for example, the CPE cost is comparatively much lower, however, the achievable throughput (with current technology) is lacking. The multi-tiered approach described herein can provides the advantages of both prior art techniques, while avoiding the drawbacks set out above.

The physical layer of the Ad-hoc Mesh Tier (AMT) can suitably be based on existing WLAN standards. (See, for example IEEE Std 802.11-1999, IEEE Std 802.11a/D6.0 and IEEE Std 802.11b/D5.5). This technology is not sufficient to handle all cases in the outdoor environment. Improvements are therefore needed. The enhancements described below will among other things aid in extending communication range and improving interference and error resilience, thereby increasing system capacity.

Since the physical layer of the AMT has similar RF characteristics to a WLAN, interoperability can be achieved purely by additional software. For example, if an AMT device has an indoor antenna, it could additionally serve as WLAN base-station, for example on a time-sharing basis.

On the link/network layer level, the presently proposed solution is potentially superior in that it does not require the concept of base-stations (master/slave approach), resulting in higher flexibility and failure resistance. Also, it does not demand the thorough network planning required for WLAN networks with multiple base-stations. This can be achieved by inband trunking and real-time adaptive network configuration. The link layer protocols will also decrease the systems self-interference.

The system described herein also implicitly handles the hidden terminal problem, whereas this poses significant scheduling problems in the WLAN approach; and can be optimised for both mobile and fixed terminals, by means of the system design being well adapted to conserving mobile battery-life.

The present network is principally adapted for outdoors use, and for deployment to cover relatively short distances to subscriber equipment rather than for long-distance trunk use (i.e. an outdoors last miles solution). It hence does not target same markets as WLANs and PANs, which are typically indoor solutions. In a suitable implementation the present network may provide a seamless wireless backhaul solution for the aforementioned technologies, in combination with which a wireless solution from, for example, a PCMCIA card may be implemented all the

way to an ISP's POP. Even though they are not shown in figure 3, WLANs and PANs can henceforth be considered to be optionally present as additional tiers underneath the AMT in figure 3.

The network comprises of three tiers: AMT, PMT and the PTP Tier.

A mesh network is built around sink nodes by adding mesh nodes. Sinks located in the area covered by one sink become connected on the mesh tier when a path of mesh nodes is available between them. In this mesh network the traffic flows from one node to another seeking the optimal route to the receiver. Though, the major part of the traffic tends to come or go to the Internet outside the radio network. Thus the traffic flow in a mesh network will be mainly from and towards sinks.

Both the AMT and PMT are mesh configurations. The AMT configuration is ad-hoc, meaning that devices may appear randomly and establish links to their geographical neighbours, thus mobile devices are supported though limitations exist to the communication during movement. The PMT configuration, in contrast, is the result of network planning. In the PMT, the devices are preferably stationary and their connections preferably fixed.

The PMT connects the AMT sinks. The PMT itself has its own sinks, which are either fixed wired backbone or PTP tier connections (see figure 3). The PMT is a mesh topology, but it may be implemented as any mesh derivative (see figure 4). LOS or the like might normally be required at this tier.

A multi-leg star topology differs from a star topology in that it allows a node to be indirectly connected to the sink (centre) node through a maximum of one other node, whereas a star topology requires each node to be directly connected to the sink. It differs from a pure mesh topology in that a pure mesh allows a node to connect to a sink through multiple hops. A multi-leg star allows usage of repeater stations to pass by obstructing objects.

The PTP tier comprises high-capacity LOS links, which serve primarily as backhaul links for the PMT and as access points for customers with extremely high bandwidth demands.

For purposes of modelling, the mesh nodes can be assumed to be distributed evenly in a square grid (see figure 5). With a maximum hop of four, there will be 64 cells per a sink (including the sink). With five, the corresponding value is 100. Note that it is assumed that the border nodes (cells) are shared with the neighbouring sinks' border nodes. Thus the total amount of nodes are 64 and 100 and not 81 and 121. The traffic generated at the sink is not by definition using the mesh network, and thus the effective node counts will be 63 and 99. The corresponding numbers for a traditional cellular network geometry, the hexagonal grid, is 47 and 74 respectively.

For the PMT tier, the maximum number of connections per node will be limited due to the fact that to connect to most nodes, the node will require another antenna. This restriction does not hold for the sink-node, the sectors of which will have to cover 360 degrees

For the purpose only of clarification and example of a capacity study for the AMT will now be considered. With an average customer throughput of, say, 200 kbit/s a sink will gather 12.6 Mbit/s (4 hops) and 19.8 Mbit/s (5 hops). Although this average rate may appear low, the bursty nature of typical traffic could make the instantaneous throughput at least an order of magnitude higher. If two radios will share the load at the sink, the capacity that each hop in the sink tier must be able to handle becomes  $\frac{1}{2} \times 19.8 \text{ Mbit/s} \approx 10 \text{ Mbit/s}$ . This is the maximum required AMT radio throughput. The maximum number of hops allowed will hence be limited by the available link capacity. The minimum total capacity needed for the AMT and PMT can't be computed by simply multiplying the number of nodes with the desired minimum capacity per node, because each hop consumes a share of the total network capacity. The more hops a data packet make the more capacity

is consumed. On average there are 2.73 hops per customer in the 4-hop case, and 3.38 hops in the 5-hop case.

$$4 \text{ hops: } (8 \times 1 + 16 \times 2 + 24 \times 3 + 15 \times 4) / 63 = 172 / 63 = 2.72$$

$$5 \text{ hops: } (8 \times 1 + 16 \times 2 + 24 \times 3 + 32 \times 4 + 19 \times 5) / 99 = 335 / 99 = 3.38$$

Thus traffic flowing to the sink will require a capacity of  $2.72 \times 12.6 \text{ Mbit/s} = 34.3 \text{ Mbit/s}$  (4 hops) and  $3.38 \times 19.8 \text{ Mbit/s} = 66.9 \text{ Mbit/s}$  (5 hops). The capacity factor using 5 hops compared to 4 is  $2.72/3.38 = 0.80$  (or  $34.3/66.9 \times 100/64$ ), while the factor of sinks necessary is 0.64. (I.e. the capacity is reduced by 20%, but there are 36% fewer sinks required).

The various network tier combinations and their applications will now be described. Five classes of environmental conditions are considered: dense urban, urban, semi-urban, semi-rural and rural. Sub-classes for these can be defined on a global scale to reflect local variations.

Example Definitions:

- Dense Urban: City centre, 4+ story buildings, and no open space between buildings except streets. Building efficiency (defined as the ratio between the sum of the total floor area (including the walls) and the land area being used) exceeds 1.00.
- Urban: Area around city centre, 2-4 story buildings, some open space between buildings may exist. Building efficiency between 0.50 – 1.00.
- Semi-Urban: City centre of small city, 1-3-story buildings, fair amount of open space around buildings. Building efficiency 0.30 – 0.50
- Semi-Rural: Single family housing area, 1-2-story buildings, lots of empty space between, sight possibly restricted by trees & fences. Building efficiency 0.10 – 0.30.
- Rural: Buildings make up a minimal part of the area. Building efficiency less than 0.10 (normally a lot less).

Utilization scenarios for these five different environments are introduced below. Obviously any combination is available in any case, but business case parameters and economics are likely to favour some combinations over others.

Thus one of the key issues of flexible network deployment can be handled by choosing the appropriate network elements.

The dense urban area is a difficult radio environment especially if LOS is required. In downtown areas business penetration is typically relatively high. Thus capacity demands become fairly high. LOS is required for this high capacity, but it is laborious to arrange, and thus the wireless solution has severe drawbacks in this environment. Nevertheless, PTP tier radios can be used to cost efficiently connect office buildings. The AMT can be used to offer service for mobile users.

Urban areas offer the highest probable customer density with a useful radio environment. Here the full concept can be utilized, as the probability for LOS is much higher than in the dense urban case. In the case that the capacity required by the customers is low, then the PTP tier can be omitted.

Semi-urban areas are most suitably handled by the AMT for access and the PMT for transport. If higher capacities are required and the distances are suitable for PTP radios, then the full concept can be considered. A PMT only solution to attract only business users is feasible.

Semi-rural areas are mainly occupied by residential users. As the area is normally quite large compared to the capacity need, the PTP tier is not necessary). For last mile(s) access to residential customers, the AMT based approach is sufficient. If only higher capacity customers are served, then the solution is PMT.

Rural areas have a very low customer density. A PMT is the most suitable. If cheaper radios are desired and lower throughput can be tolerated, then AMT radios with additional directional antennas can be used. The network topology here is fully dependent on particular case but could be a multi-leg star, simple mesh or a combination of these (see figure 6).

Figures 7 to 10 illustrate the deployment of the AMT in an urban environment. In this environment NLOS (dotted lines in the figures) operation is beneficial, helping to reach all potential customers. As the customer base and customer density grow after initial implementation, the need for NLOS operation gradually diminishes. At some level it may be that only LOS operation is considered. At this stage additional technology (e.g. 60 GHz radios) can be introduced.

With higher customer density the cell size decreases. This can be implemented by restricting constraints on power control so as to limit the transmission range of transceivers in the system. The transmit power is adjusted continually to the minimum required level for the information to get through with a required level of accuracy. This has an interference reducing effect. Nevertheless, performance may advantageously be strengthened by usage of space diversity (directional antennas). Traditional directional antennas are not preferred in the present case as beam direction must be adjusted according to the position of the other end of a radio link. Smart and semi-smart antennas will be preferred.

Directional antennas and an advanced frequency re-use scheme may be called upon when the LOS probability increases. In that case, not only does the end point lie within LOS, but also an increasing number of the other devices. This is a limiting factor to shrinking cells. Thus systems with worse propagation characteristics and more available bandwidth are foreseen. Even optical transmission can be considered at this point at least for the fixed installations.

In rural areas the customer density might be very low. There is a clear need for extended range. In this case the AMT can be deployed in a LOS manner (LOS is generally easily achieved in rural areas, and hence a weak constraint). This might call for locating fixed antennas on high constructions and even professional installation and alignment of the antennas. Optional very high gain directional antennas could be used to extend the range further. Nevertheless, the mesh functionality can be used when available creating redundant paths (see figure 11).



Since the PMT should be capable of serving as sink tier for the AMT, the capacity of each PMT node should be (in a typical case for present level data throughputs) at least, say, 12.8Mbps (matched to the 4 hop max. mesh case) or 20.0 Mbps (matched to the 5 hop max. mesh case). Hence, as a stand-alone application, the PMT will typically serve as the lowest tier of the backhaul network for businesses or apartment complexes, which have a private (wired or wireless) LAN, or as MAN to connect clusters of buildings like in university campuses.

Since entirely isolated networks are exceedingly rare, a PMT will, in practice, probably be provided with have sinks to wireless PTP nodes and/or wired network backbones.

A flexible increase in range by decreasing the throughput should enable usage of the PMT tier as primary tier to provide access for customers in (semi) rural areas.

The PTP Tier consists of high throughput ( > 100 Mbps) point-to-point links, which can serve as backbone network for the above PMT, and as access point for customers with very high data-rate demands or a combination thereof. The only feasible sinks for this tier are wired "internet backbones".

As with the PMT above, a trade-off between throughput and range should be facilitated to allow effective usage in both high-density (urban) and low-density (rural) areas.

Deployment of the complete concept as shown in figure 3 will be most feasible in urban areas with either solely residential customers, or a mixture of residential and business customers. The AMT would then be deployed to facilitate low-cost connections to individual residences and businesses with low throughput needs, while the PMT would serve as sink tier for the AMT and to facilitate access for businesses with medium throughput demands. The PTP Tier in this case serves as backhaul tier for the PMT and to facilitate access for businesses with high throughput demands.

AMT transmissions are made up of control slots and data slots (see below). The transmission of the control slots may be done in one of the channels in the highest band (due to the allowance of the highest power in this band), which can be selected arbitrarily by the operator. During the transmission of these control slots, all other channels will be silent. Data slots will be scheduled in the remaining time, spread out over all channels, where the scheduling will take the maximum allowed power in that channel into consideration.

Band (GHz)	Max. Output Power
5.15 – 5.25	200 mW
5.25 – 5.35	400 mW
5.725 – 5.825	800 mW

Alternatively, the AMT could be implemented in the 2.4-2.4835 GHz ISM band (see figure 12). This band requires a minimum 6 dB bandwidth of 500 kHz (see IEEE 802.16 System Requirements v4) and allows a peak output power of 1 Watt (omni-directional). WLAN standards (see IEEE Std 802.11-1999 and ETSI/BRAN HIPERLAN, Type 2 "Requirements and architectures for wireless broadband

The aim of the network management in the PMT is to allow the network operator to change any desired parameter or protocol functionality in any remote device without any onsite maintenance. For this purpose, all devices could be SNMP-



- Configuration management - with a configuration management protocol allowing the operator to set such parameters as IP addresses, RX/TX parameters etc.
- Fault management – allowing the operator to access a device's error and warning logs, reset devices and shut down devices. The protocols will allow the operator to set various reporting levels and set the severity of errors to be reported to the central network management system.
- Performance management - Performance management protocols in each device monitor the device's link quality. A device may be configured to report prolonged periods of unacceptable link quality to an operator's central management system. Such a feature is generally not desired for a AMT device, but very desirable for the PMT and PTP Tier devices.
- Security management - Security management protocols will allow the operator to set keys in each device and to validate the key of each device. Each device should be able to validate access attempts.
- Accounting management - Accounting management protocols may allow the operator to set the maximum throughput of traffic originating from the device. This could include limiting the bursty throughput as well as the total traffic.
- Flow management - allowing the operator to force the direction of traffic, overruling the automatic routing protocols.

- Upgrading management - The network can allow the operator to upgrade the software in one specific device by means of uni-cast, or in a group of devices by means of multi-cast.

All of the above features should preferably be available to an operator from a single NMS, and should be accessible while the device is operational (with exception of certain upgrading and fault management functions, which may interrupt the device's operation for a short duration).

It is envisaged that the network described herein will be predominantly used for transportation of "internet applications": both traditional flexible applications, such as FTP and web-browsing; and time-critical applications such as voice-over-IP and audio/video streaming. Applications which require IPSEC or like security, and multicast and broadcast applications may also be supported.

Significant advantages of the present system lie in its flexibility of adaptation and deployment of the network, as well as in the plurality of services that a provider can offer to its customers and the range of devices that can be connected.

The fact that the present system provides a flexible wireless solution for traffic concentrations up to at least 155 Mbps, and that the system reconfigures itself when new sinks are added, gives the service provider a flexible tool to match the bandwidth demands of its customers, and hence to scale up the network as desired. In contrast, a typical wired solution requires estimation of fixed capacity years ahead since capacity can only be increased with significant investment.

The relative flexibility of adaptation and scalability of the present system also give a service provider flexibility of deployment, since the provider can match his network to the current demand, and modify it easily and only when traffic-patterns change. This allows the provider to make a much lower initial investment than for a wired solution.

Since the CPE devices are principally intended for short-distance (wholly or semi-) LOS use, the cost of the RF part of a CPE of the present system can be kept fairly low. Also, since the basic access scheme is DSSS, but alternative high performance (and more expensive) schemes such as OFDM are optional, devices varying in performance and cost can be easily connected to the network, increasing the number of devices. On top of this, the AMT is intended for the ISM bands, for which the RF equipment is significantly cheaper than for the PMT devices, which may use the LMDS bands. Hence the hierarchical layering of the proposed system can reduce costs compared to a pure LMDS-band based network.

The design of the present system inherently allows a service provider to offer a wide variety of service packages. Not only because user priorities allow the provider to assign preferred customers and flexible maximum bandwidth, but also because the full system concept consists of three natural tiers of services. This allows the provider to not only have small-demand customers connect to the AMT, but also to have larger-demand customers connect to the PMT or even PTP tier, without changing the functionality of the system.

Due to connection redundancy, the present system is likely to be more tolerant of link failure than, for example, star and tree networks. When a link breaks, a device in the present system can reroute its traffic over its other links. Even a sink-node failure will not result in loss of connectivity, as the traffic can (though with lower efficiency) be redirected to another sink-node.

Networks that rely on CSMA or similar contention-based access protocols tend to break down or deliver drastically lower throughput as the number of active devices grows large. This is due to the increased probability of collisions and the back-off mechanisms. The proposed network however does not suffer from such effects as reservation mechanisms are used. Even when the number of devices grows large compared to the number of control-slots available in a superframe, redefinition of the superframe size in the present system could readily allow for

more control-slots and hence facilitate access for more devices. On the other hand, when few devices are present, the superframe could be defined to be smaller, so as not to waste resources.

Reliability can be further enhanced provided by the modulation agility, which would allow a device to switch to modulations less sensitive to interference if necessary, while it enables selecting high throughput modulations when the link-quality is sufficient.

Additional reliability may be provided by using an FFT engine (which may in any event be provided for use with OFDM implementation) for spectral analysis to detect and avoid channels with high interference.

The higher tiers of the present system may call for a relatively large amount of bandwidth, which is only available in high frequency ranges where propagation loss is generally severe. This may limit the range of such higher-tier links. Care should thus be taken in designing the system since the higher tiers must span over the lower tiers mandating somewhat longer link-lengths. This issue is less pertinent when the AMT is dense, as the sinks, and thus the nodes of the tiers above it, lie closer together.

Care should also be taken to handle any delays that may arise. For example, due to the multi-tier and (in the mesh tiers) multi-hop solution, CPE-POP delay in the present system may be larger compared to a single-tier network (which however requires significantly more wiring). Also, due to the adaptive routing in the AMT, the number of hops between two nodes may change, making estimation of the peer-to-peer delay difficult.

It may be envisaged that the present system may be further enhanced by:

- (i) The use of hybrid ARQ;
- (ii) Antenna diversity, adjustable antenna lobe direction, smart antennas, a semi-smart antenna concept or the like;



AGC	Adaptive Gain Control
AMT	Ad-Hoc Mesh Tier
ARP	Address Resolution Protocol
BRAN	Broadband Radio Access Networks
CCITT	International Telegraph and Telephone Consultative Committee
CCA	Carrier Controlled Access
CCK	Complementary Code Keying
CPE	Customer Premise Equipment
CRC	Cyclic Redundancy Code
CSMA	Carrier Sense Multiple Access
DSSS	Direct Sequence Spread Spectrum
DSL	Digital Subscriber Line
ETSI	European Telecommunication Standardization Institute
FCC	Federal Communications Commission (USA)
FFT	Fast Fourier Transform
ICMP	Internet Control Message Protocol
IP	Internet Protocol
IPSEC	Secure Internet Protocol
ISDN	Integrated Services Digital Network
ISM	Industry, Science & Medical
ISP	Internet Service Provider
ITU	International Telecommunication Union
LAN	Local Area Network
LMDS	Local Multipoint Distribution Service
LOS	Line Of Sight

MAN	Metropolitan Access Network
MMDS	Multi Media Distribution System
NLOS	Non Line Of Sight
NMS	Network Management System
OFDM	Orthogonal Frequency Division Modulation
PAN	Personal Access Network
PMT	Pre-configured Mesh Tier
PMP	Point-to-Multi-Point
POP	Point of Presence
PPP	Point to Point Protocol
PTP	Point-to-Point
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RF	Radio Frequency
RIP	Router Information Protocol
RX	Receive
SLIP	Serial Line Internet Protocol
SNMP	Simple Network Management Protocol
SOHO	Small Office Home Office
TCP	Transmission Control Protocol
TFTP	Trivial File Transfer Protocol
TX	Transmit
UDP	User Datagram Protocol
U-NII	Unlicensed National Information Infrastructure
WLAN	Wireless Local Access Network
WLL	Wireless Local Loop

The present invention may include any feature or combination of features disclosed herein either implicitly or explicitly or any generalisation thereof irrespective of whether it relates to the presently claimed invention. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

**CLAIMS****1. A communications system comprising:**

a first network comprising a plurality of first network subscriber units and a first network sink node unit capable of wireless communication with the first network subscriber units; and

a second network geographically at least partly overlapping the first network and comprising a plurality of second network subscriber units and a second network sink node unit capable of wireless communication with the second network subscriber units; and

a dedicated connection between the first network sink node unit and a second network unit capable of communication in the second network, whereby a first network subscriber unit may be provided with a communication path to another second network unit.

**2. A communications system as claimed in claim 1, wherein wireless communication in the first network is independent of wireless communication in the second network.**

**3. A communications system as claimed in claim 2, wherein wireless communication in the first network is in a different frequency band from wireless communication in the second network.**

**4. A communications system as claimed in any preceding claim, wherein the first network comprises a plurality of first network sink node units with which the first network subscriber units are capable of wireless communication.**

**5. A communications system as claimed in claim 4, comprising a plurality of a dedicated connections, each dedicated connection being between a respective first network sink node unit and a respective second network unit whereby a first network subscriber unit may be provided with a communication path to another second network unit.**

6. A communications system as claimed in any preceding claim, comprising:

a third network geographically overlapping the second network and comprising a plurality of third network subscriber units and a third network sink node unit capable of wireless communication with the primary third network unit; and

a dedicated connection between a second network sink node unit and a third network unit capable of communication in the third network, whereby a second network subscriber unit may be provided with a communication path to another third network unit.

7. A communications system as claimed in claim 6, wherein wireless communication in the first network and in the second network is independent of wireless communication in the third network.

8. A communications system as claimed in claim 7, wherein wireless communication in the first network and in the second network is in a different frequency band from wireless communication in the third network.

9. A communications system as claimed in any preceding claim, wherein the second network comprises a plurality of second network sink node units with which the second network subscriber units are capable of wireless communication.

10. A communications system as claimed in claim 9 as dependent directly or indirectly on claim 6, comprising a plurality of a dedicated connections, each dedicated connection being between a respective second network sink node unit and a respective third network unit whereby a second network subscriber unit may be provided with a communication path to another third network unit.

11. A communications system as claimed in any preceding claim, wherein the said communication is data communication.

12. A communications system as claimed in claim 11, wherein the said communication is packet data communication.

13. A communications system as claimed in any preceding claim, wherein the said communication uses an internet protocol.

14. A communications system as claimed in any preceding claim, wherein the said communication in the first network is radio communication.

15. A communications system as claimed in any preceding claim, wherein the said communication in the second network is radio communication.

16. A communications system as claimed in any of claims 7 to 15 as dependant directly or indirectly on claim 6, wherein the said communication in the third network is radio communication.

17. A communications unit for operation in a communications system including a first network comprising a plurality of first network subscriber units; and a second network geographically at least partly overlapping the first network and comprising a plurality of second network subscriber units and a second network sink node unit capable of wireless communication with the second network subscriber units; the communications unit being operable as a first network sink node unit capable of wireless communication with the first network subscriber units, and having a dedicated connection to a second network unit capable of communication in the second network, whereby a first network subscriber unit may be provided with a communication path to another second network unit.

18. A method for providing a communication path in a communications system comprising: a first network comprising a plurality of first network subscriber units and a first network sink node unit capable of wireless communication with the first network subscriber units; and a second network geographically at least partly overlapping the first network and comprising a plurality of second network

23. A communications system as claimed in claim 22, comprising a plurality of a dedicated connections, each dedicated connection being between a respective

first network sink node unit and a respective second network unit whereby a first network communication terminal may be provided with a communications access to the second network.

24. A communications system as claimed in any of claims 19 to 23, comprising:

a third network geographically at least overlapping the second network and comprising a plurality of third network communication terminals and a third network sink node unit capable of wireless communication with the third network communication terminals; and

a dedicated connection between a second network sink node unit and a third network unit capable of communication in the third network, whereby a second network communication terminal may be provided with communications access to the third network.

25. A communications system as claimed in claim 24, wherein wireless communication in the first network and in the second network is independent of wireless communication in the third network.

26. A communications system as claimed in claim 25, wherein wireless communication in the first network and in the second network is in a different frequency band from wireless communication in the third network.

27. A communications system as claimed in any of claims 19 to 26, wherein the second network comprises a plurality of second network sink node units with which the second network communication terminals are capable of wireless communication.

28. A communications system as claimed in claim 27 as dependent directly or indirectly on claim 24, comprising a plurality of a dedicated connections, each dedicated connection being between a respective second network sink node unit and a respective third network unit whereby a second network communication terminal may be provided with a communications access to the third network.

29. A communications system as claimed in of claims 19 to 28, wherein the said communication is data communication.

30. A communications system as claimed in claim 29, wherein the said communication is packet data communication.

31. A communications system as claimed in any of claims 19 to 30, wherein the said communication uses an internet protocol.

32. A communications system as claimed in any of claims 19 to 31, wherein the said communication in the first network is radio communication.

33. A communications system as claimed in any of claims 19 to 32, wherein the said communication in the second network is radio communication.

34. A communications system as claimed in any of claims to 25 to 33 as dependant directly or indirectly on claim 24, wherein the said communication in the third network is radio communication.

35. A communications unit for operation in a communication system including a first network comprising a plurality of first communication terminals; a second network geographically at least partly overlapping the first network and comprising a second sink node and a plurality of second communication terminals capable of wireless communication with the second sink node; the communications unit being operable as a first sink node capable of wireless communication with the first communication terminals and of operation as a second communication terminal for providing the first communication terminals with communications access to the second network.



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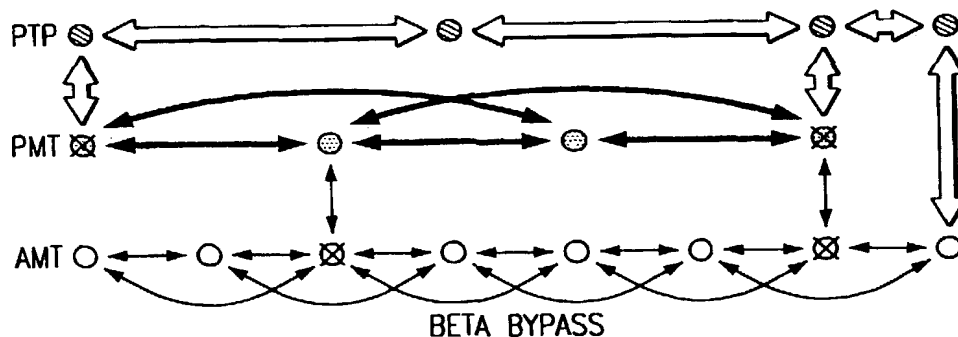
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(54) Title: **MULTILAYER TELECOMMUNICATIONS NETWORK**



(57) Abstract: A communications system comprising: a first network comprising a plurality of first network subscriber units and a first network sink node unit capable of wireless communication with the first network subscriber units; and a second network geographically at least partly overlapping the first network and comprising a plurality of second network subscriber units and a second network sink node unit capable of wireless communication with the second network subscriber units; and a dedicated connection between the first network sink node unit and a second network unit capable of communication in the second network, whereby a first network subscriber unit may be provided with a communication path to another second network unit.

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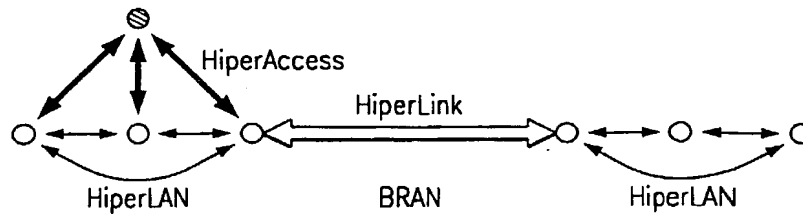


FIG. 1

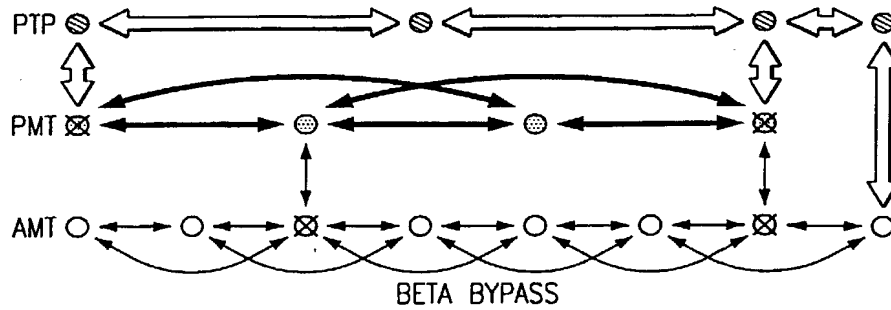


FIG. 2

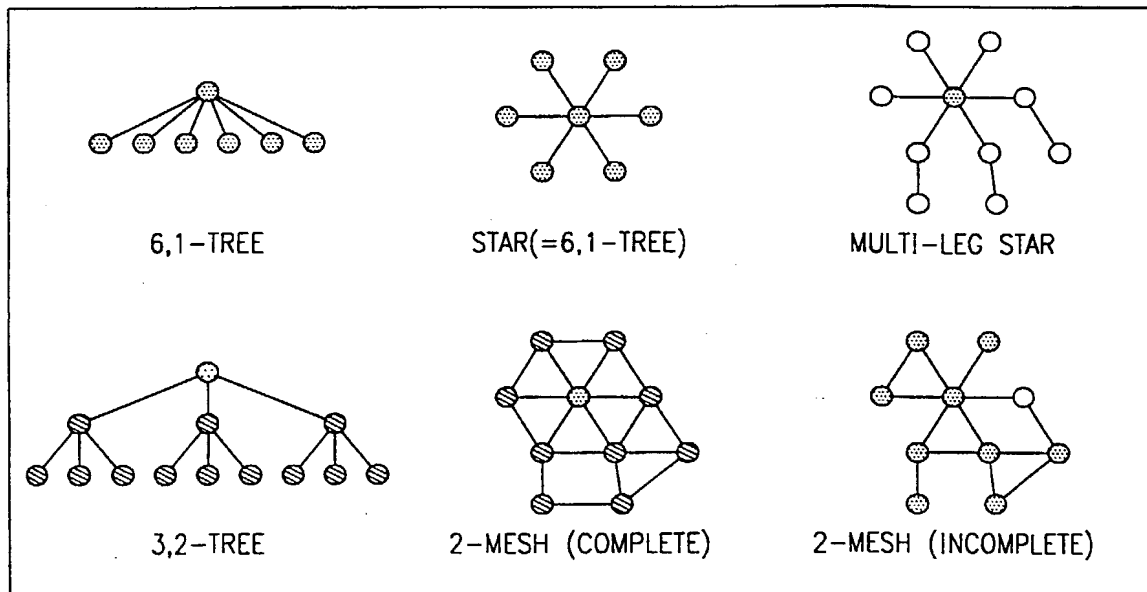
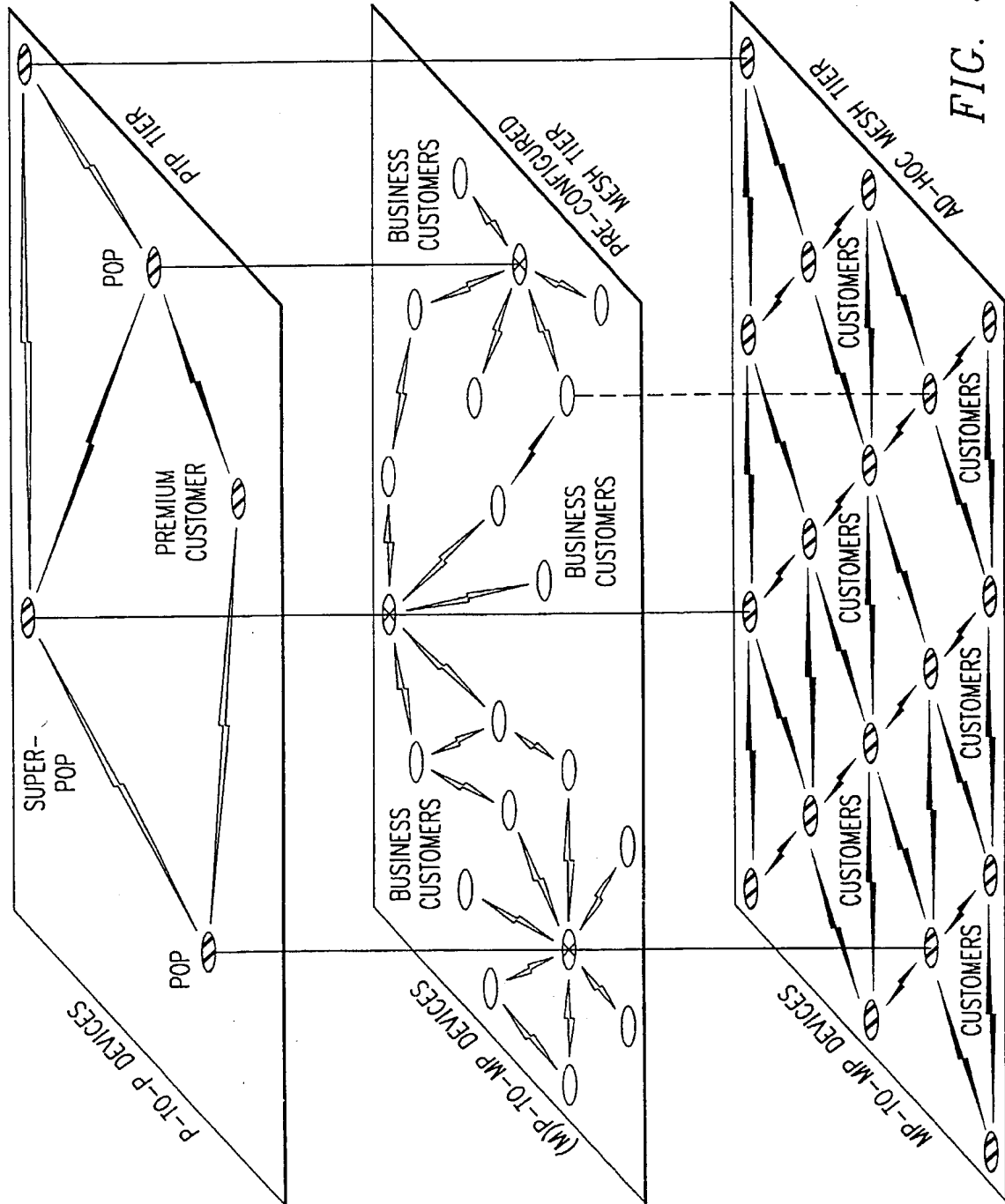


FIG. 4



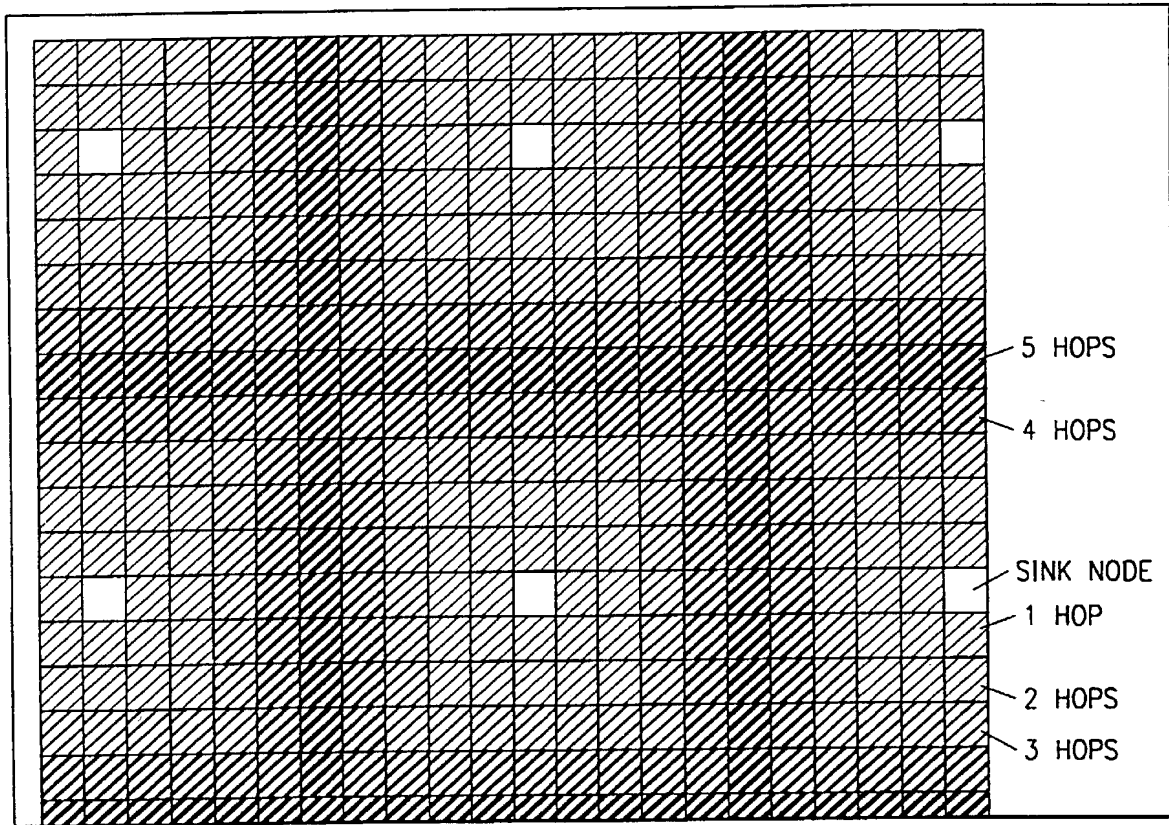


FIG. 5

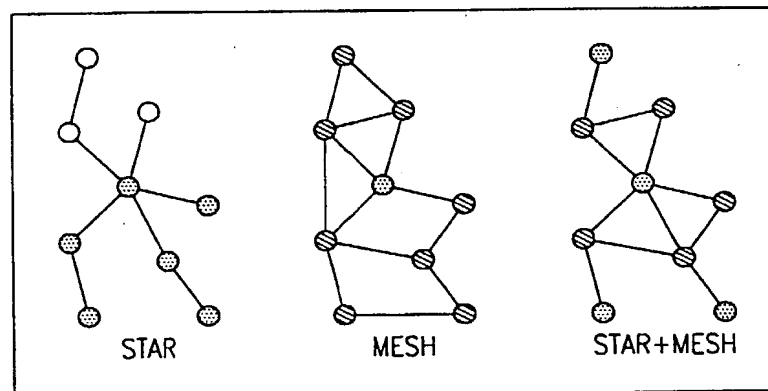


FIG. 6

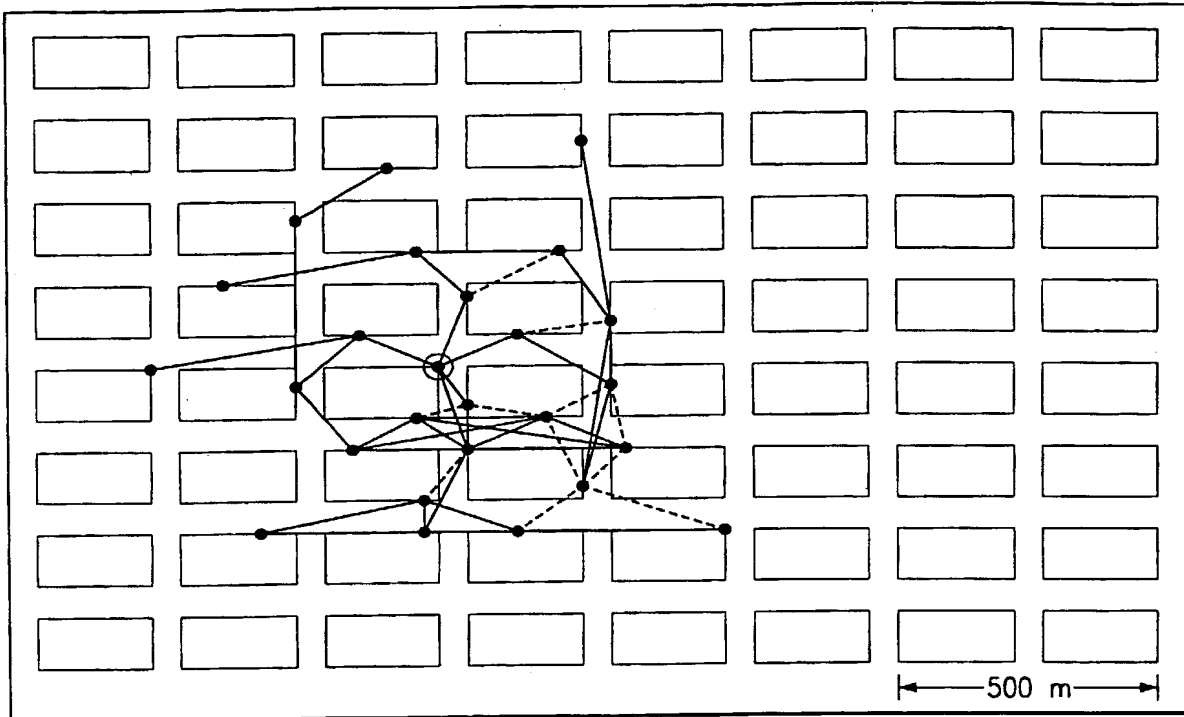


FIG. 7

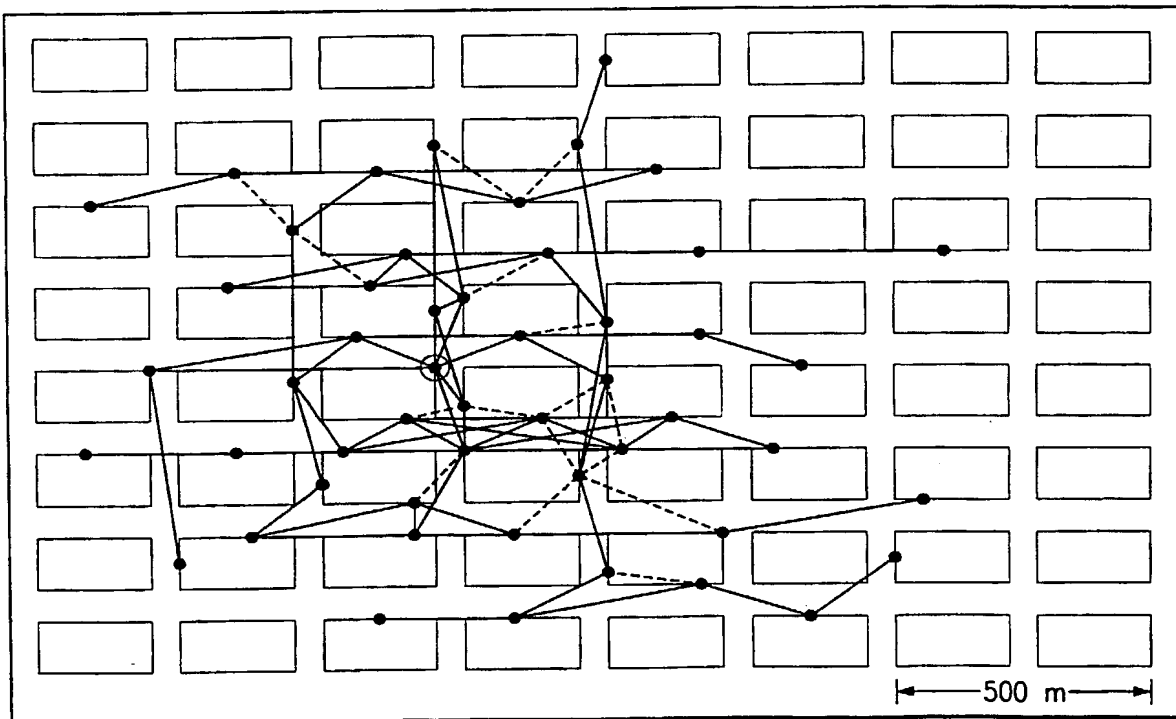


FIG. 8

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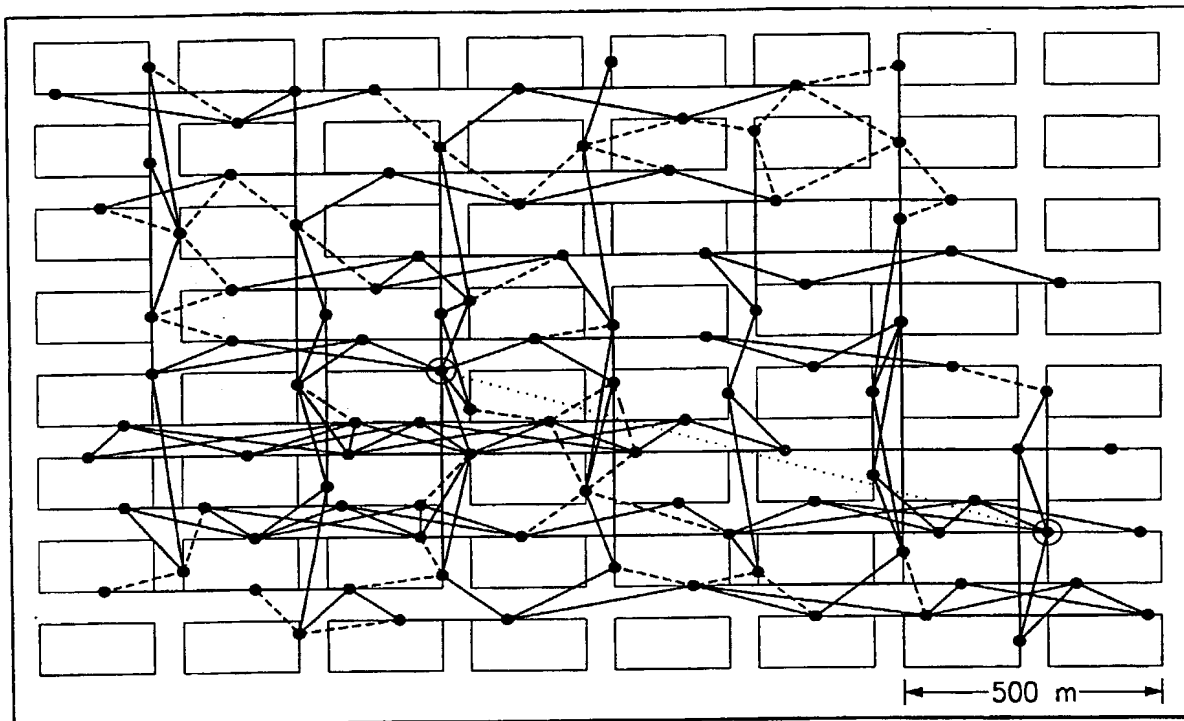


FIG. 9

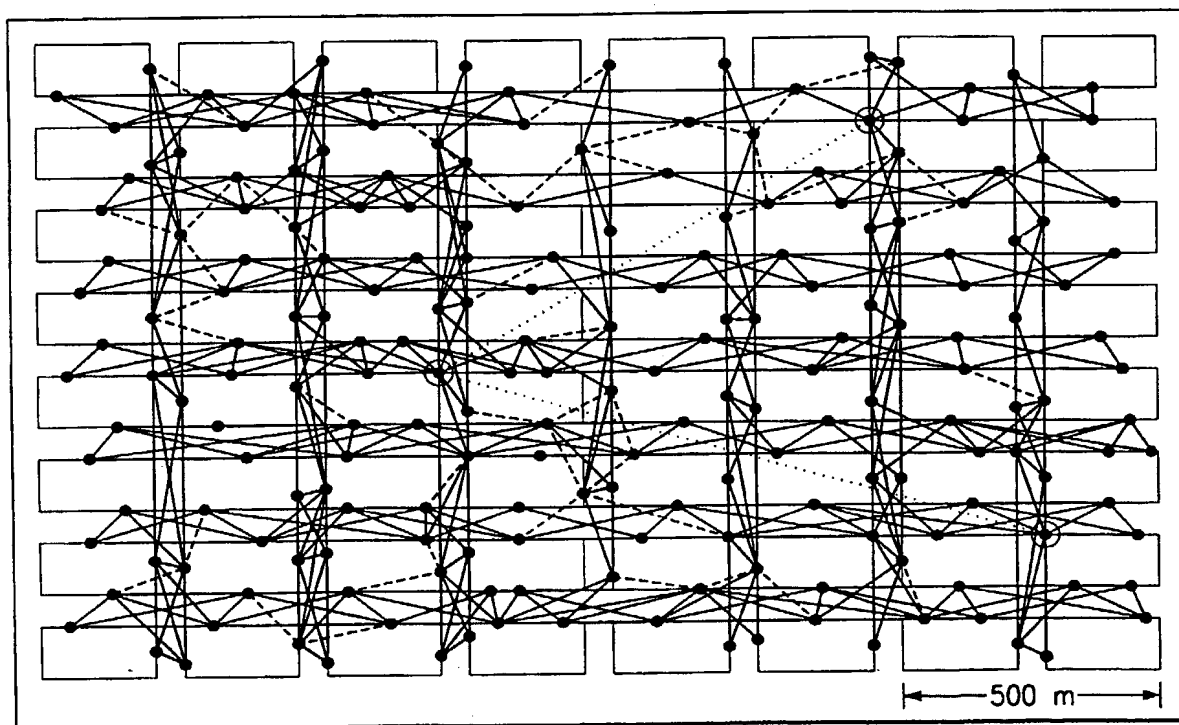


FIG. 10

SUBSTITUTE SHEET (RULE 26)

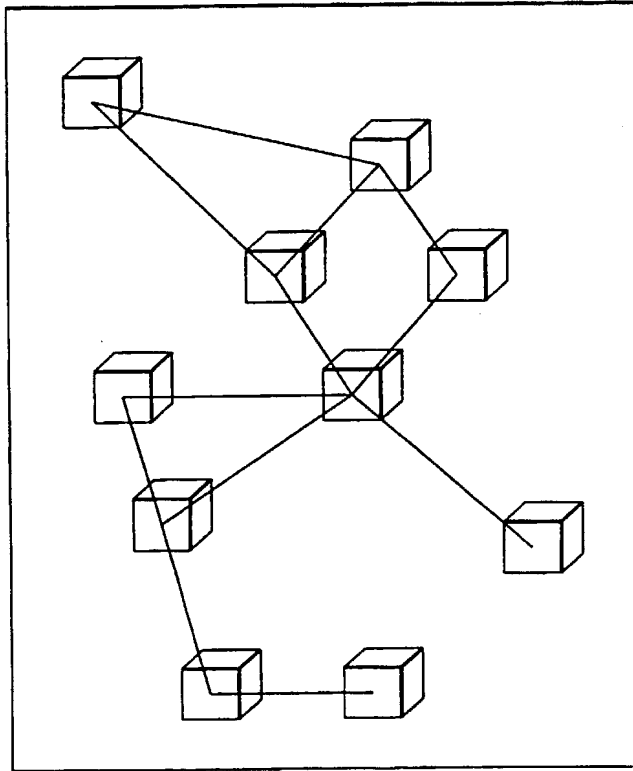


FIG. 11

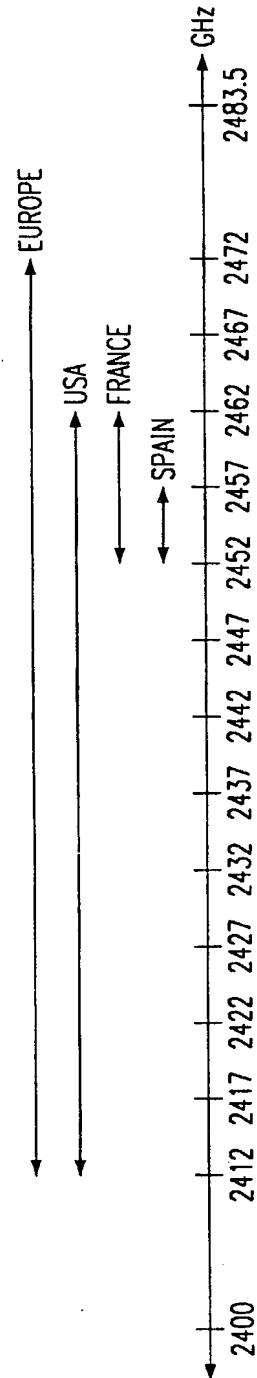


FIG. 12

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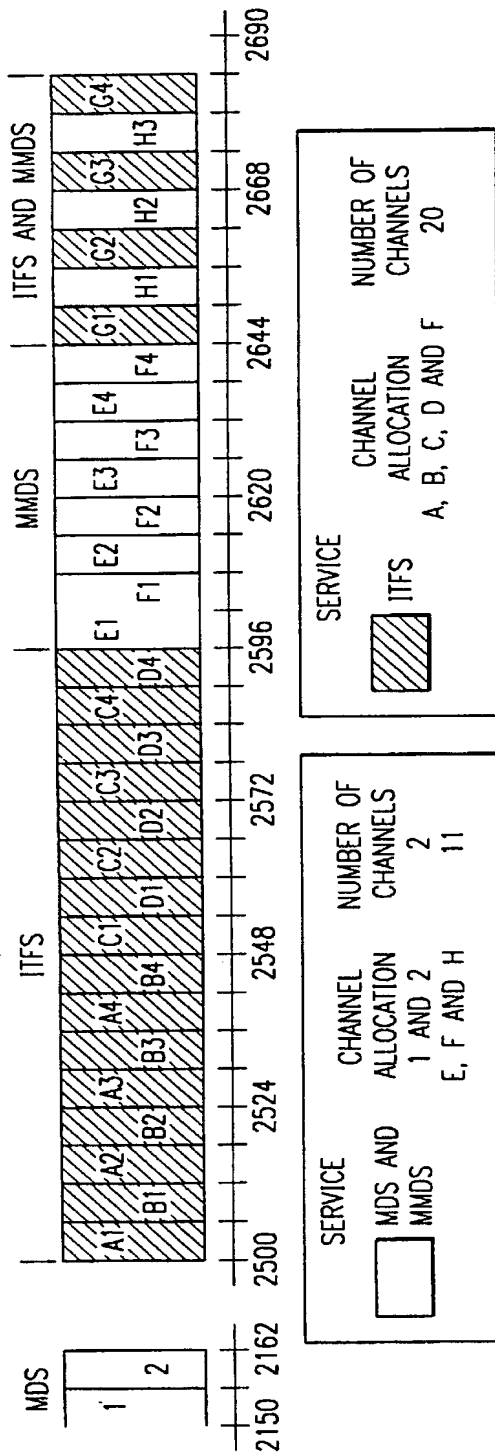


FIG. 13

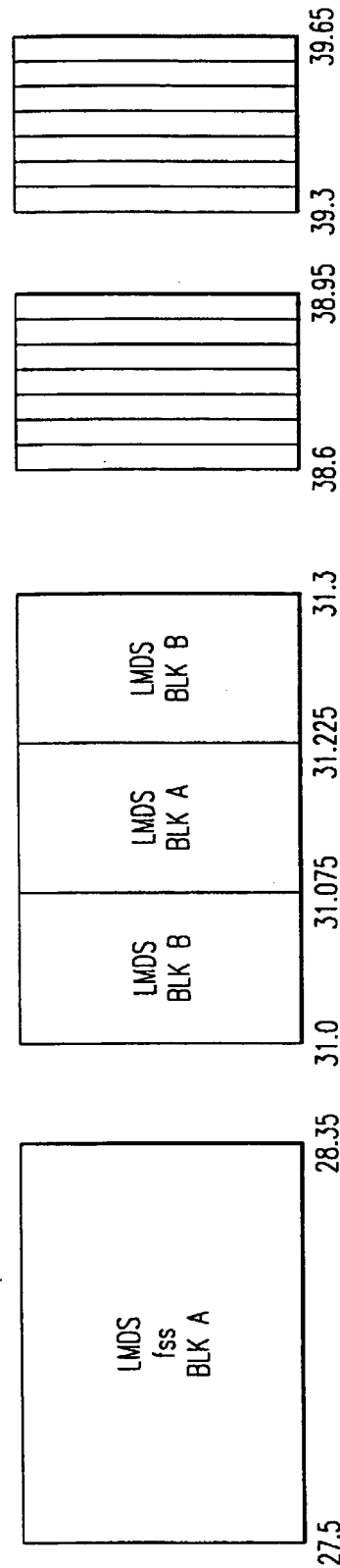


FIG. 14



DOCKET NO. NOKI14-00025

PATENT

DECLARATION AND POWER OF ATTORNEY

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention, design or discovery entitled:

“MULTILAYER TELECOMMUNICATIONS NETWORK”

the specification of which was filed on March 27, 2002 and assigned Serial No. 10/089,326.

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above;

I acknowledge the duty to disclose to the Office all information known to me to be material to the patentability of this application as defined by Title 37, Code of Federal Regulations, § 1.56.

I hereby claim no foreign priority benefits under 35 U.S.C. § 119 of any foreign application(s) for patent or inventor's certificate on which priority is claimed.

**PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION AND  
ANY PRIORITY CLAIMS UNDER 35 U.S.C. §119(a)-(d)**

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

COUNTRY (OR INDICATE IF PCT)	APPLICATION NO.	DATE OF FILING (Day, Month, Year)	PRIORITY CLAIMED UNDER 37 USC 119	
PCT	PCT/IB00/01434	27/09/00	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
Great Britain	9923070.8	29/09/99	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
			<input type="checkbox"/> Yes	<input type="checkbox"/> No

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**CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)**  
(34 U.S.C. §119(e))

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below:

SERIAL NO.	DATE FILED	STATUS

**CLAIM FOR BENEFIT OF EARLIER US/PCT APPLICATIONS**  
**UNDER 35 U.S.C. § 120**

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose to the Office all information known to me to be material to patentability as defined in § 1.56 which became available between the filing date of any prior application(s) and the national or PCT international filing date of this application.

SERIAL NO.	DATE FILED	STATUS

I hereby appoint:

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Linda Beach, Registration No. 36,446  
Jubin Dana, Registration No. 41,400  
Wayne DeMello, Registration No. 48,601  
Reginald Finn, Registration No. 39,975  
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and,

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14

Robert H. Kelly, Registration No. 33,922  
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my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith, and to file and prosecute any international patent applications filed thereon before any international authorities under the Patent Cooperation Treaty.

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(214) 922-9221

Atty. Docket No.:

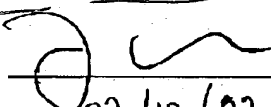
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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1005

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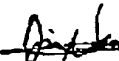
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